Forschungszentrum Jülich
in der Helmholtz-Gemeinschaft

From 

Spin-Filtering Studies at COSY

Detector Setup and Organization

to Polarized Antiproton EXperiments

The Goal

The ANKE Silicon Tracking Telescopes

Questions

Organization

Spin Filtering Studies

Measure beam (Anti) proton polarisation built-up

One detection system for $p\vec{p},\, p\vec{d},\, p\alpha,\; \bar{p}p\; elastic\,?$
Is silicon a good choice for a ‘universal detector’?

$\rightarrow$ Large overlap with spectator detection @ ANKE

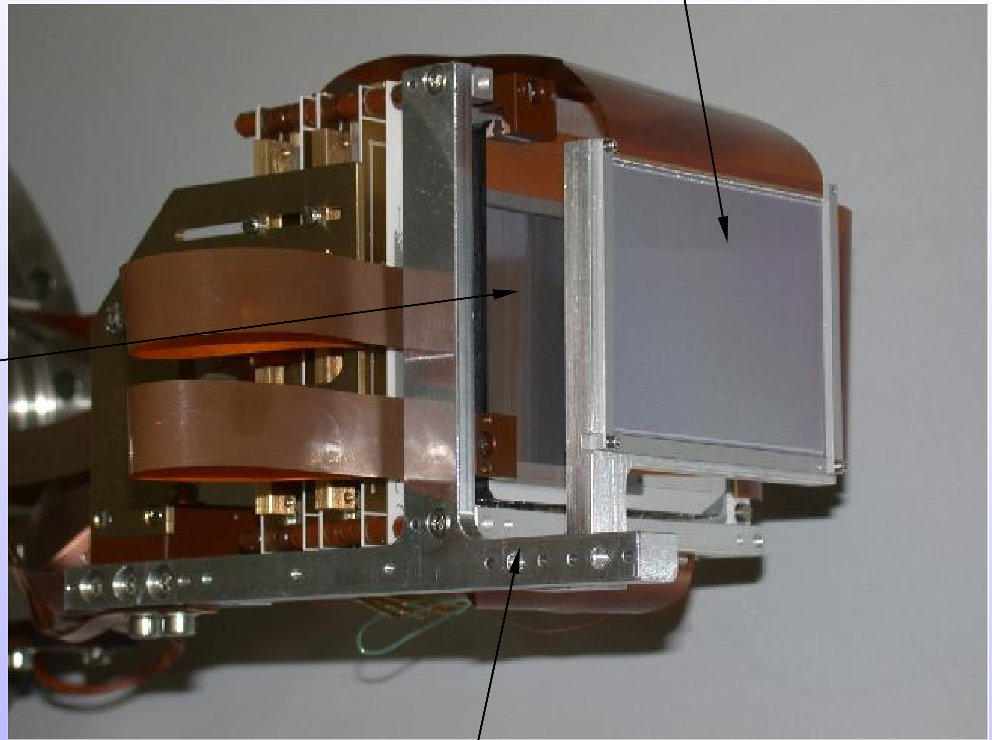
The ANKE Silicon Tracking Telescopes

Silicon Tracking Telescopes

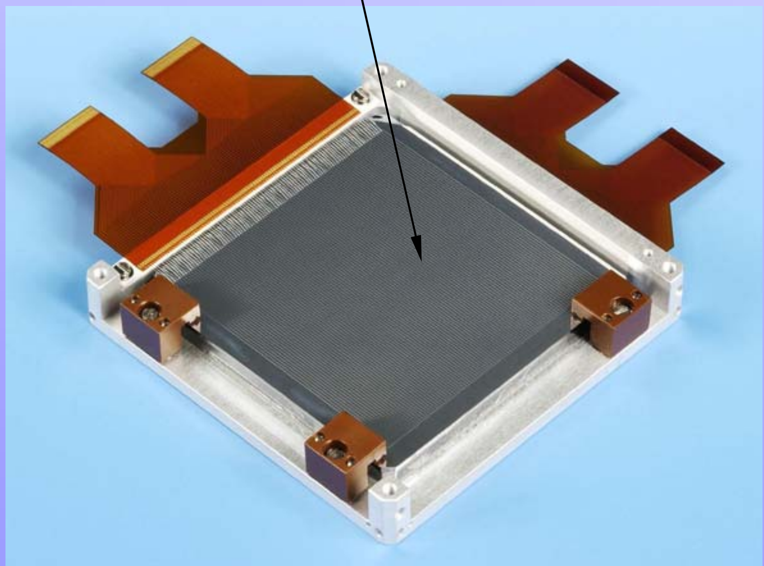
Range telescopes with up to 4 layers of x,y silicon detectors provide

1. ΔE/E particle identification and tracking
2. Energy determination of stopped particles
3. Self-triggering
4. Time-resolution

69 μm Si Detektor



5100μm thick Si(Li) detector



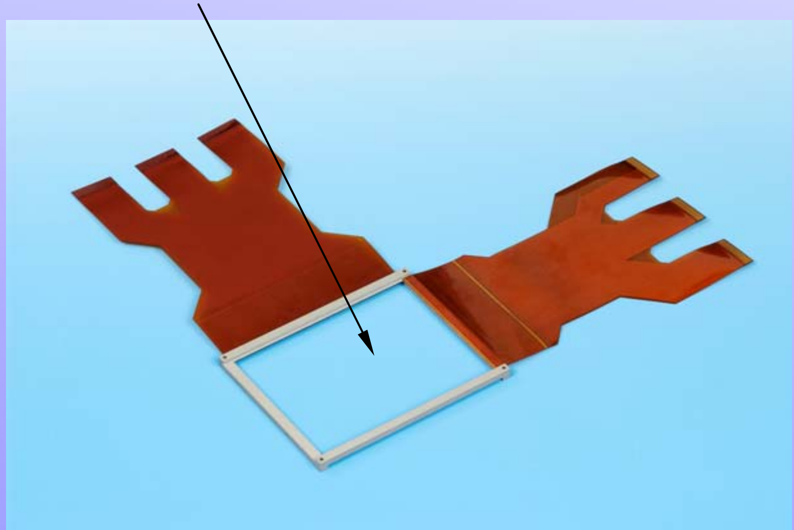
300 μm Si detector (is missing in this picture)

Silicon Tracking Telescopes: Spectator Proton Detectors

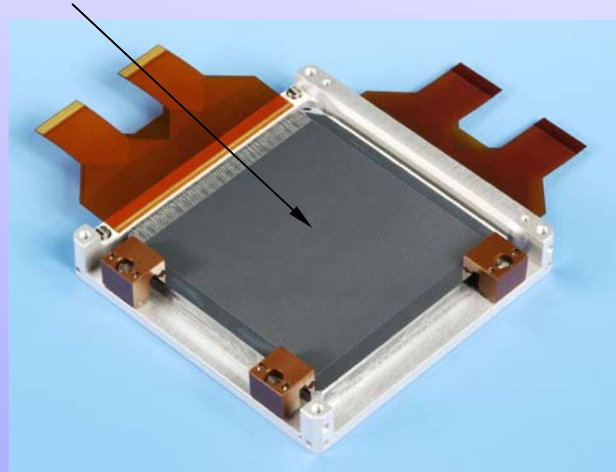
Identification, tracking and total energy = 4-momentum of spectator protons

$$69\,\mu m,\ \Delta E < 2.5\,MeV,\ 66\cdot 52\,mm^2,\ \sim 0.4\,mm\ pitch$$
$$300\,\mu m,\ \Delta E < 6.2\,MeV,\ 66\cdot 52\,mm^2,\ \sim 0.4\,mm\ pitch$$
$$500\,\mu m,\ \Delta E < 8.2\,MeV,\ 66\cdot 52\,mm^2,\ \sim 0.4\,mm\ pitch$$
$$5500\,\mu m,\ \Delta E < 40\,MeV,\ 64\cdot 64\,mm^2,\ \sim 0.7\,mm\ pitch$$

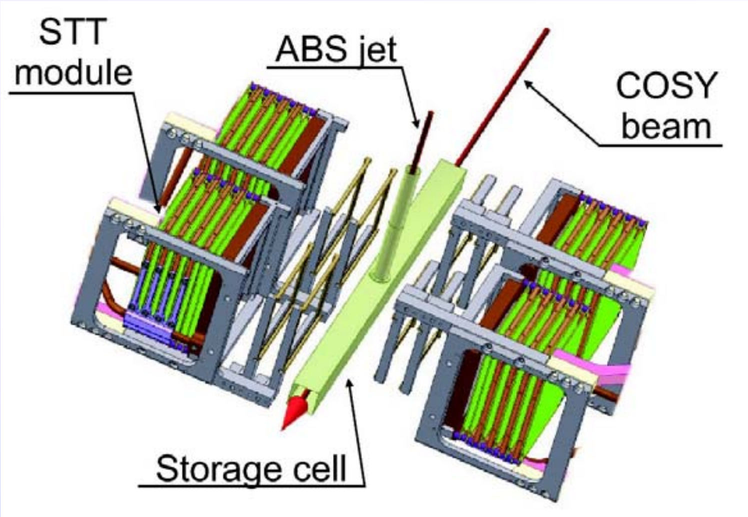
69/300/500 μm Si-detector,
Micron Semiconductur, England

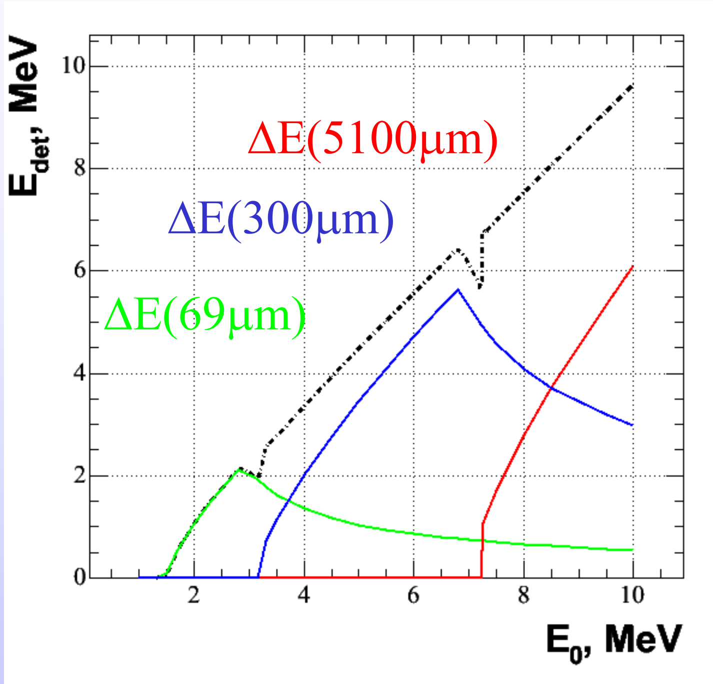


5100–20000μm thick Si(Li) detectors,
IKP Semiconductor Laboratory

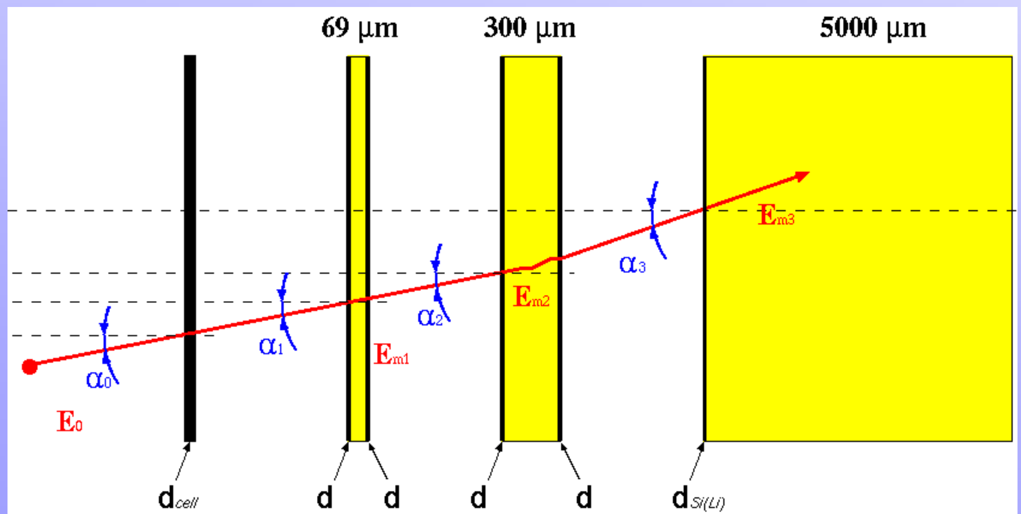


Silicon Tracking Telescopes: Dead Layer Losses



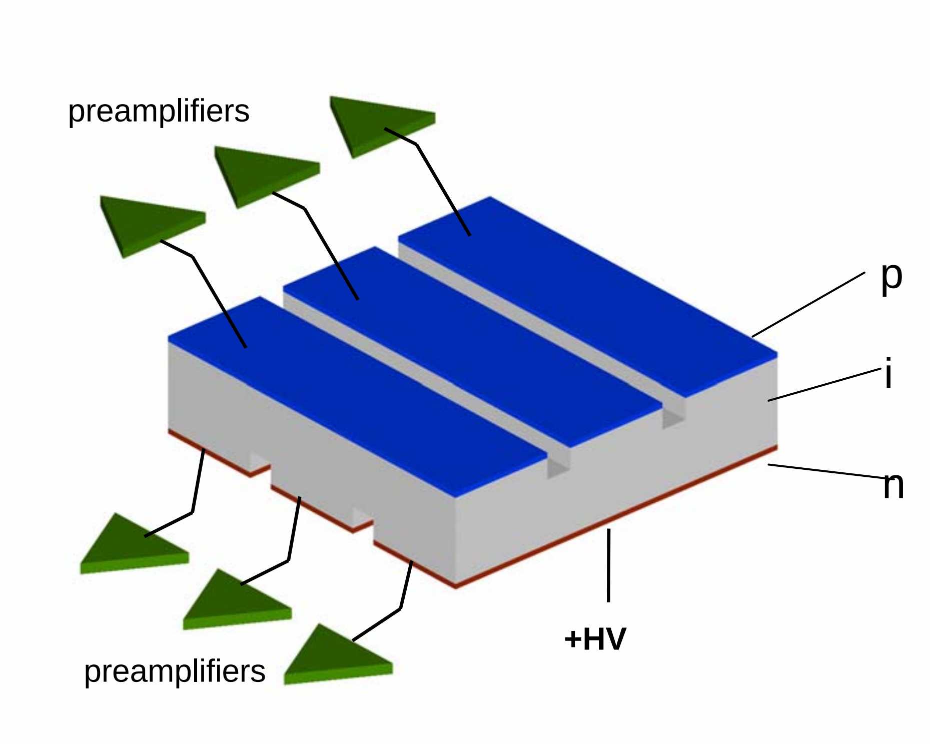


d_{cell}=25μm
d~5μm

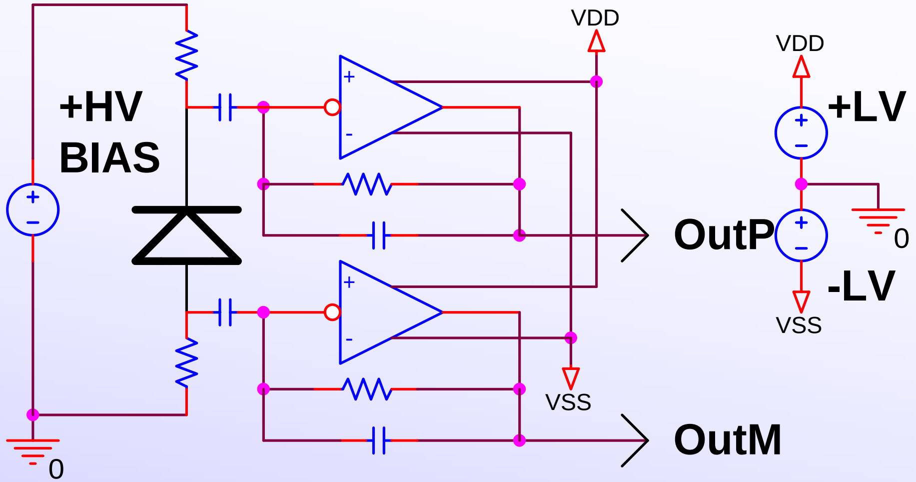


Electronics

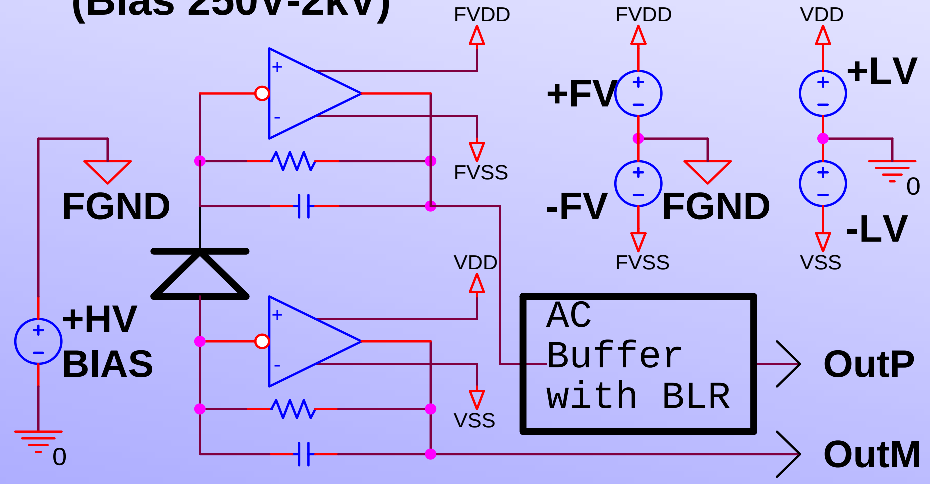
Silicon Tracking Telescopes: Floating Power Supply



position-sensitive detector



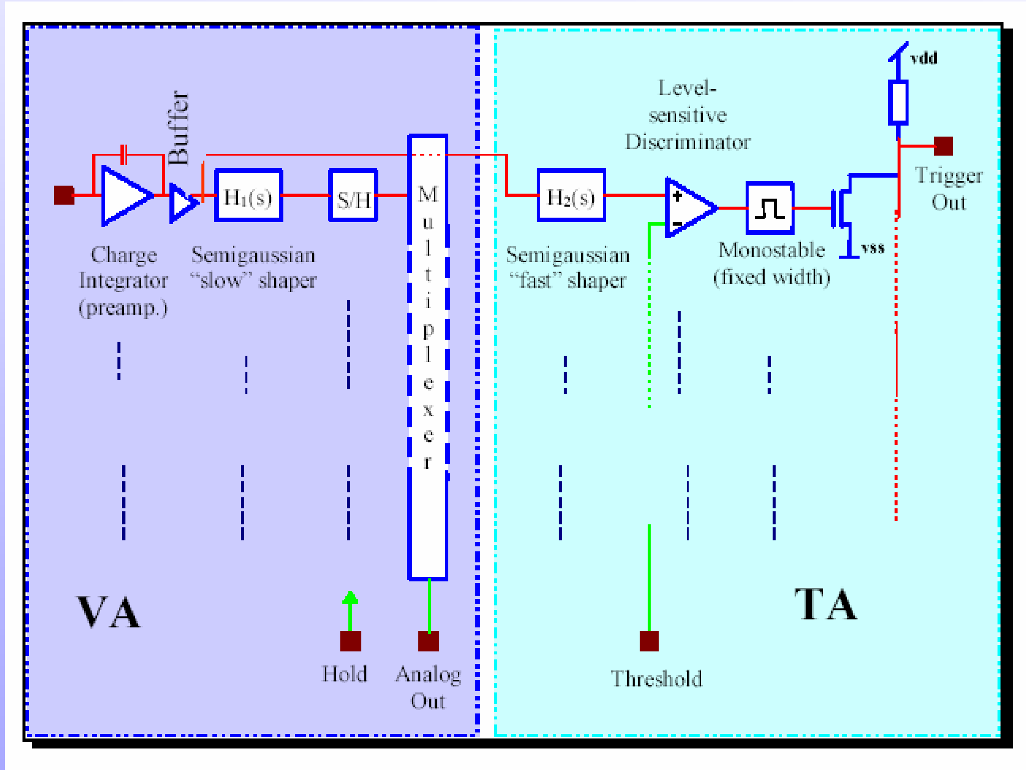
Capacitive connection of preamplifiers (Bias 250V-2kV)



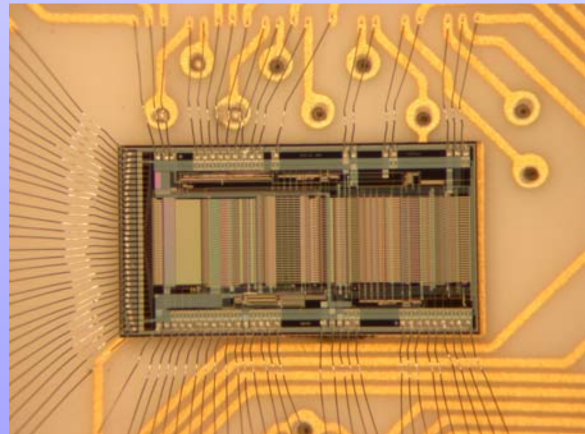
Floating power supply connection of preamplifiers (Bias 0V-250V)

Silicon Tracking Telescopes: Front-End Chips

VA32TA2 front-end electronics: IKP and ideas/Norway

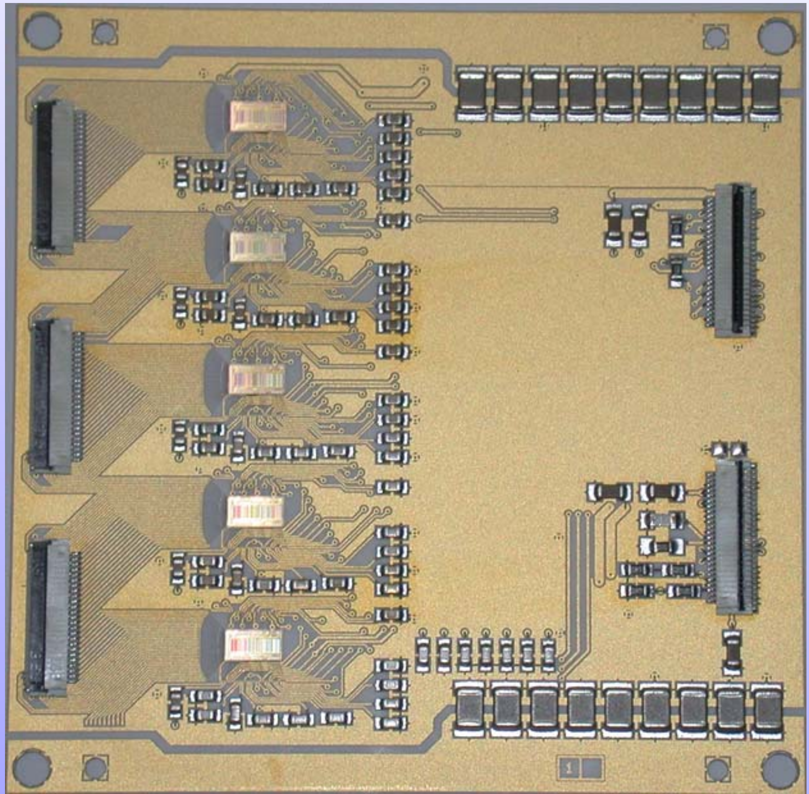


Number of channels	32
Technology	0.8μm CMOS
Power supply	±2V
Power dissipation	3mW/channel
Linear range	11MeV (±500fC)
Slow shaper (Peaking Time)	2 μs
Fast shaper (Peaking Time)	80ns
Minimum Threshold	40keV (1.8fC)
Threshold homogenity	4keV (0.2fC)
Time walk (0.05-11MeV)	~100ns
Energy resolution (C_{det}=60pF)	890e$^-$ (sigma)
Readout frequency	10Mhz

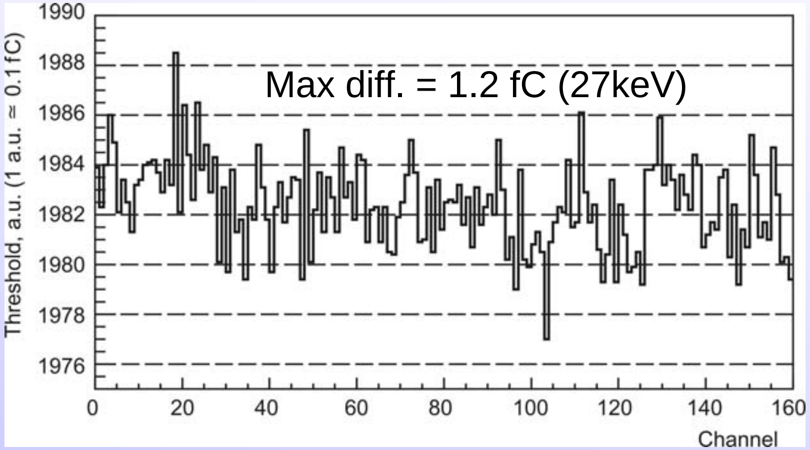


Silicon Tracking Telescopes: Homogeneous Trigger Efficiency

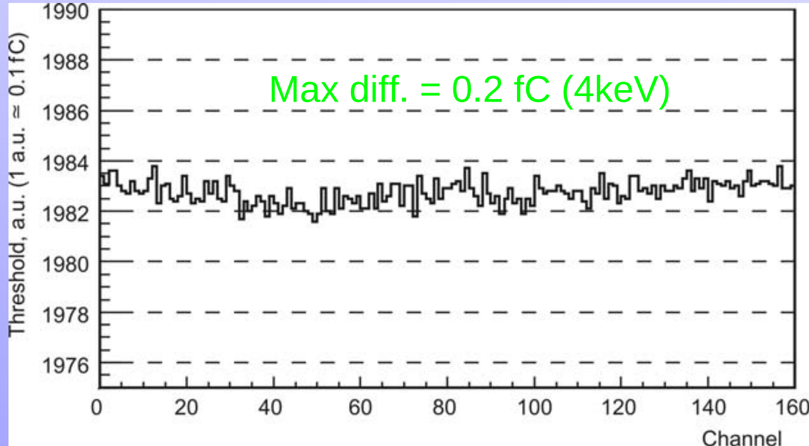
Threshold tuning of VA32TA2 based front-end electronics



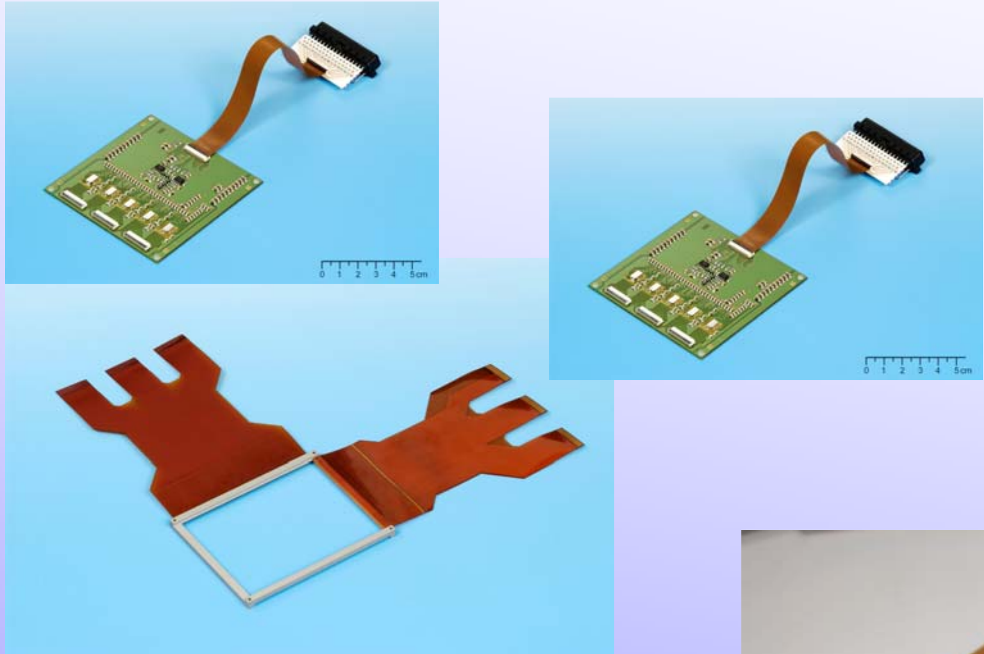
Before threshold DAC-tuning…



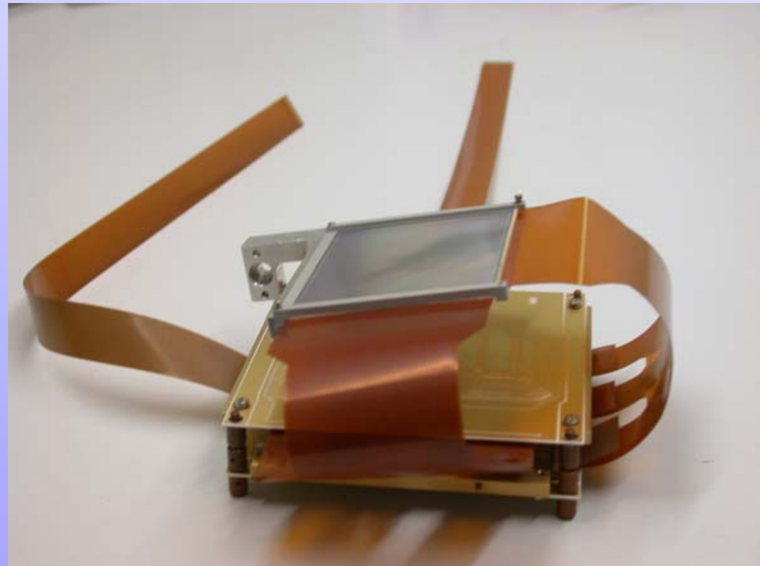
After threshold DAC-tuning…



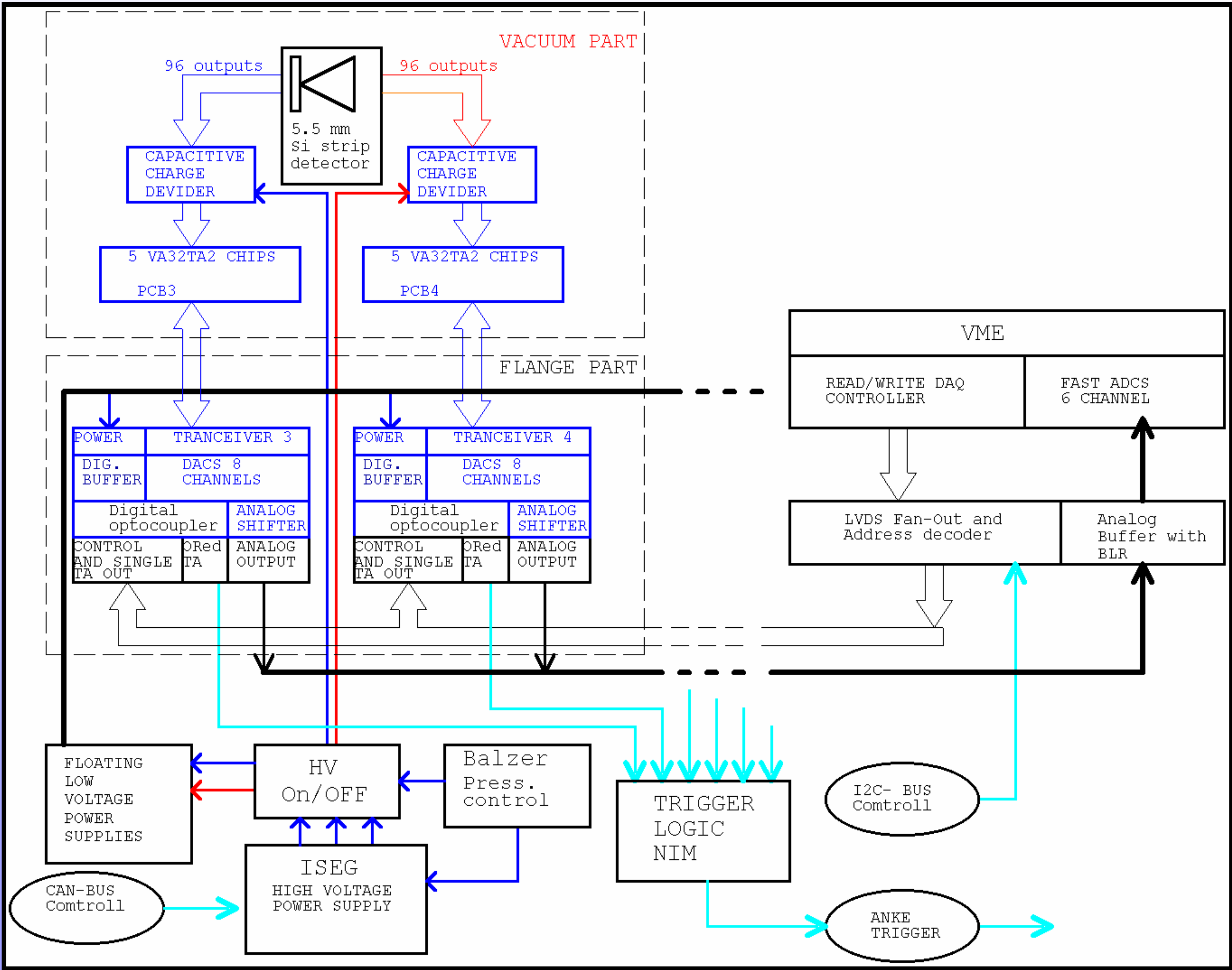
Silicon Tracking Telescopes: UHV Assembly



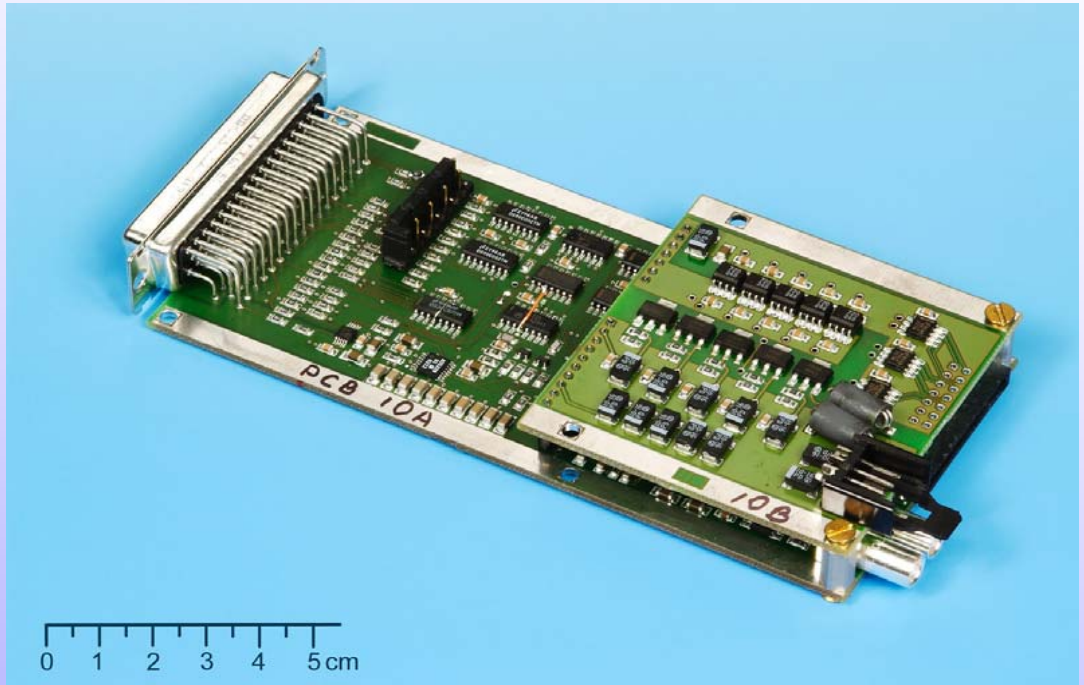
- 160 channels preamplifiers
- Dynamic range: 1-100 MIPs
- self-triggering
- 5(10) MHz read-out



Silicon Tracking Telescopes: Block Scheme



Silicon Tracking Telescopes: Front-end Electronics

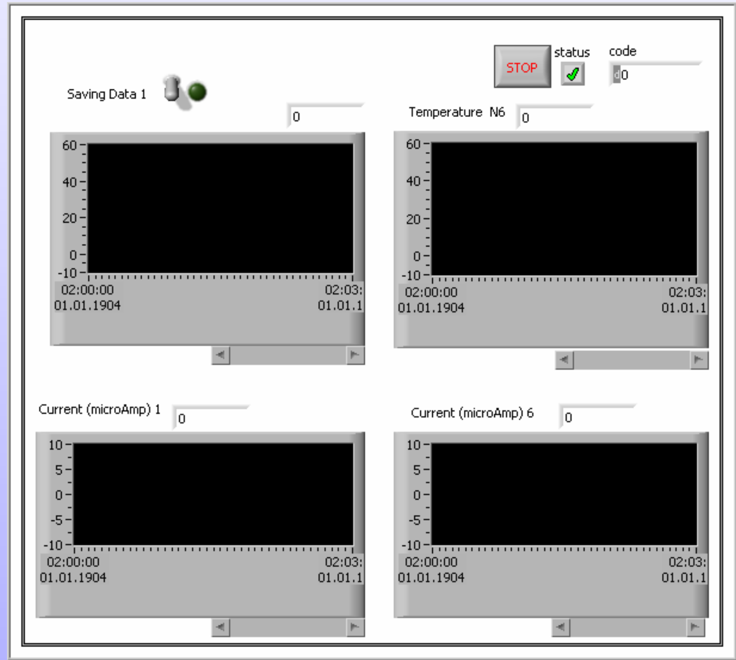


Flange card (two per detector):

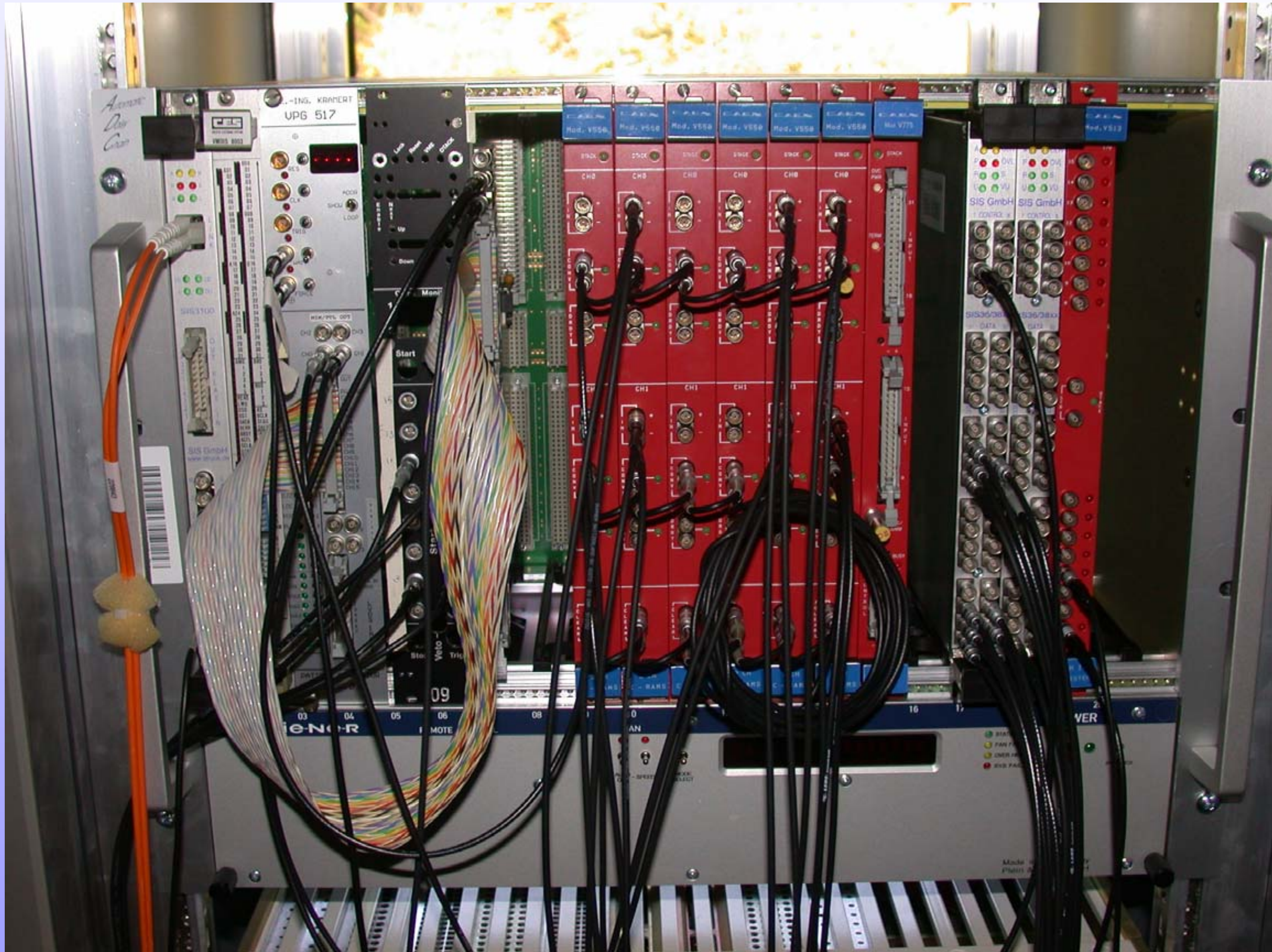
- Opto decoupling of digital input/output buffers
- analog output buffer with variable gain
- floating power supplies
- DACs
- I2C-Bus ADCs (bias current, temperature, etc.)

I2C-Bus Lab View control:

- detector current
- detector temperature
- temperature of vacuum electronics



Silicon Tracking Telescopes: VME System



Silicon Tracking Telescopes: ZEL System

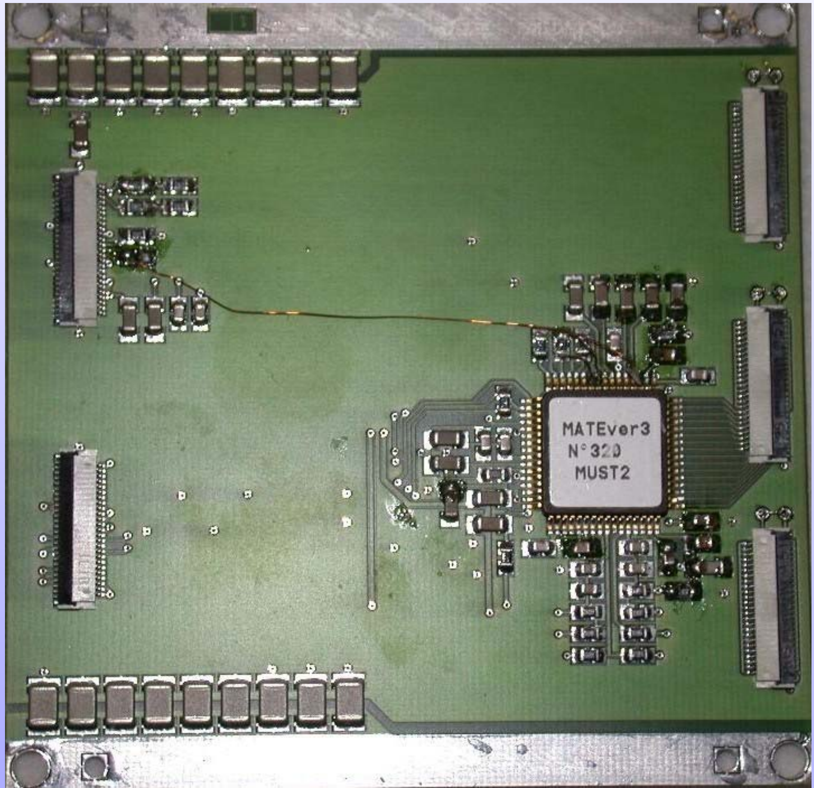
One module per detector:

- Two 12Bit ADCs, 10MHz sampling
- One sequencer per detector
- Hardware common-mode correction

→ Prototype under test

Time Resolution

Silicon Tracking Telescopes: Time Resolution



Prototype board for Saclay/Mate 3 chip

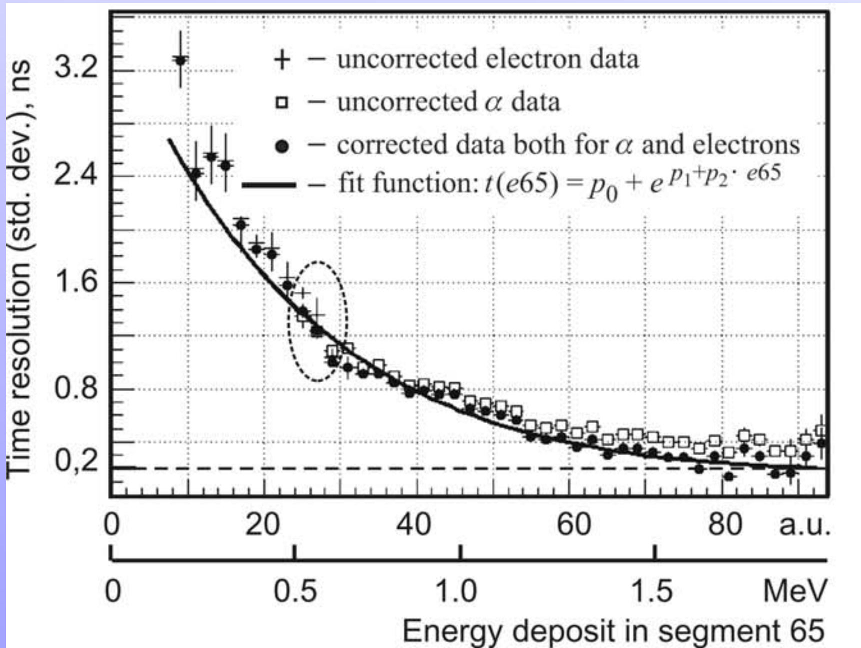
Parameters of the Saclay/MATE 3 front-end chip

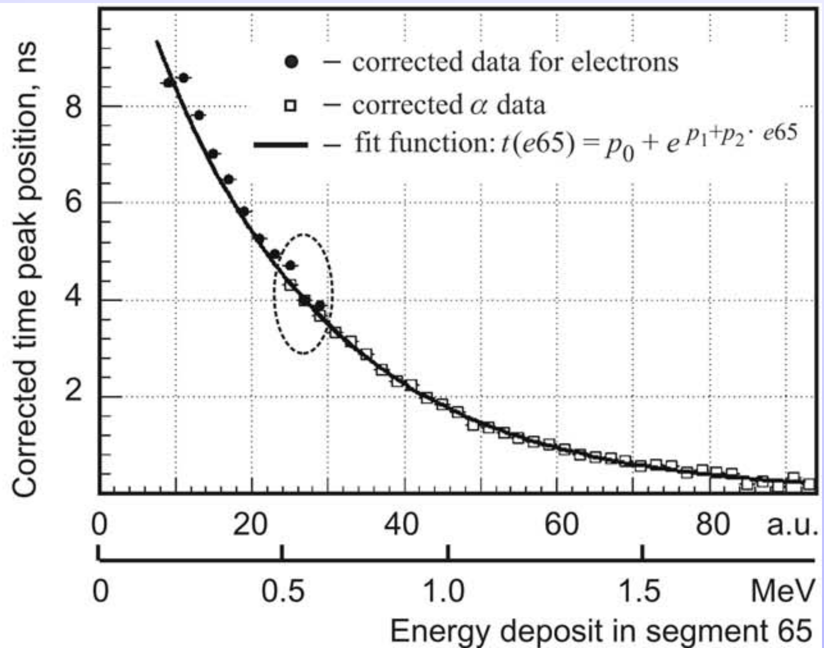
Number of channels	16
Technology	0.8μm BICMOS
Power supply	±2.5V
Power dissipation	30mW/channel
Linear energy range	50MeV (± 2220fC)
Slow shaper (Peaking Time)	1μs and 3μs
Fast shaper (Peaking Time)	22ns
Minimum threshold	0.4MeV (8fC)
Time resolution (E>1.5MeV)	$\sigma \leq 0.3$ns
Energy resolution (C_{det}=60pF)	σ=1530e^-
Readout frequency	2MHz (energy & time)
Common stop	(Reset needed)

STT Time Resolution: MATE Results

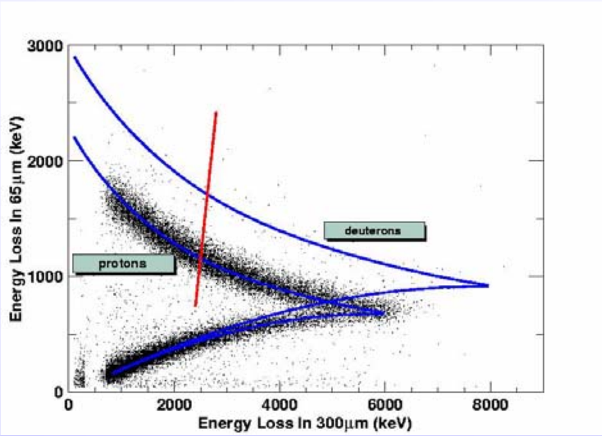
Combined MATE3 Time-Resolution Results

Energy deposit, MeV	0.2	0.5	1	1.5
σ, ns	3.0 ± 0.5	1.5 ± 0,3	0.7 ± 0.2	0.3 ± 0.2

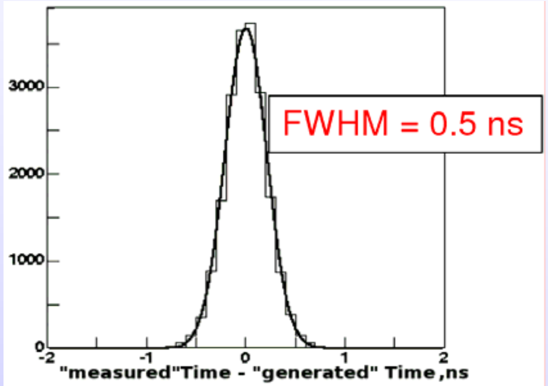




STT Time Resolution: Combined Time Resolution

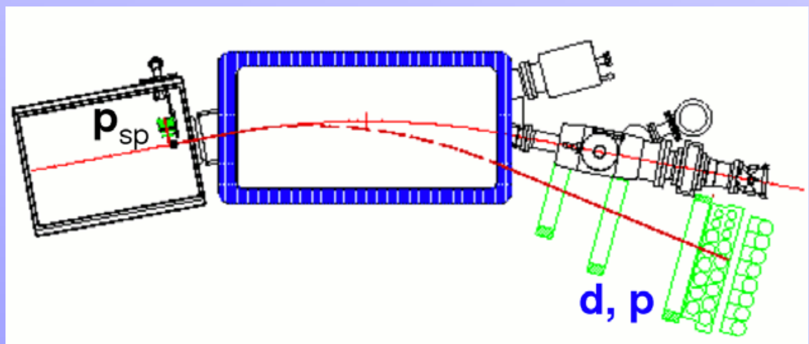


→ **Combine first two detectors**

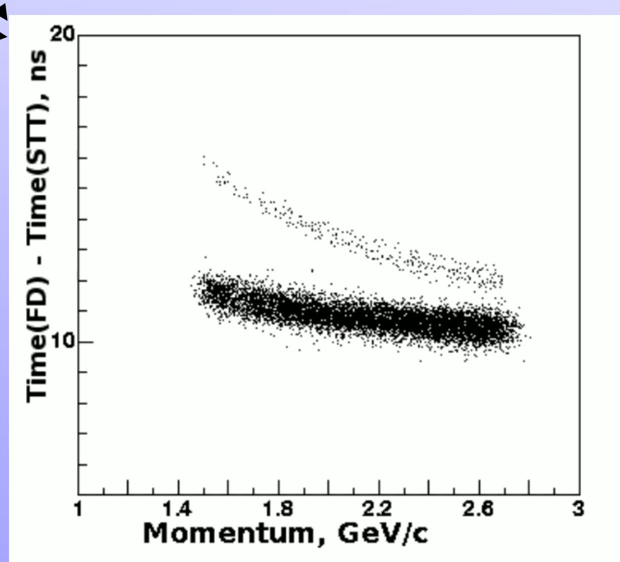


$$pp \to pp\pi\pi\pi$$

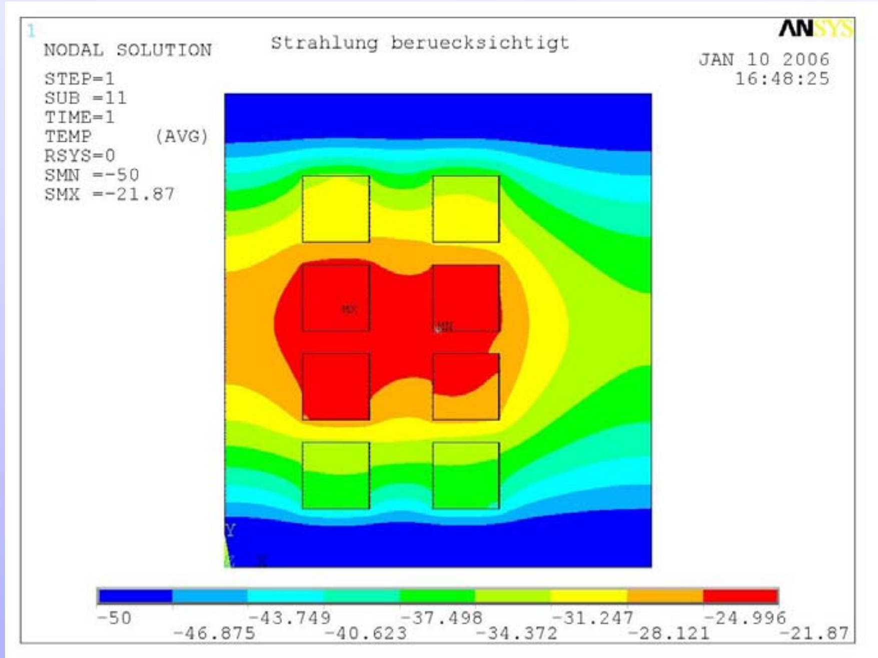
$$pd \to pd\pi\pi\pi$$



p-d separation



STT Time Resolution: 128 Channel MATE Board



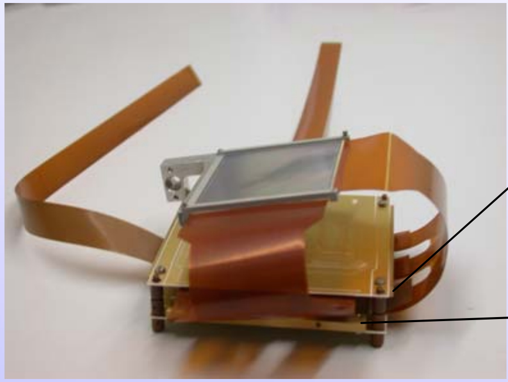
128 channel MATE 3 ceramic
~ 5W power dissipation

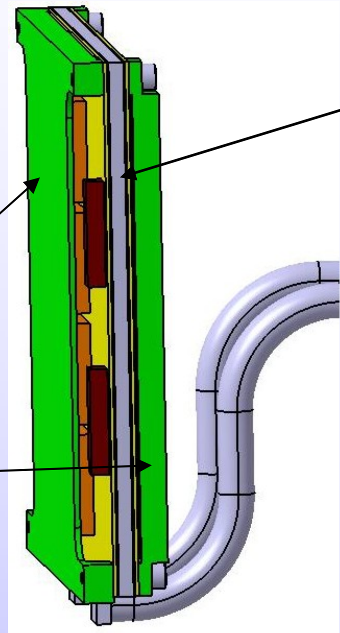
Parameters of front-end chip MATE3

Number of channels	16
Technology	0.8μm BICMOS
Power supply	±2.5V
Power dissipation	30mW/channel
Linear energy range	50MeV (± 2220fC)
Slow shaper (Peaking Time)	1μs and 3μs
Fast shaper (Peaking Time)	22ns
Minimum threshold	0.4MeV (8fC)
Time resolution (E>1.5MeV)	σ≤0.3ns
Energy resolution (C_{det}=60pF)	σ=1530e^-
Readout frequency	2MHz only (energy & time)
Common stop	(Reset needed)

Silicon Tracking Telescopes: Cooling

1 cooling plate for 2 front-end boards

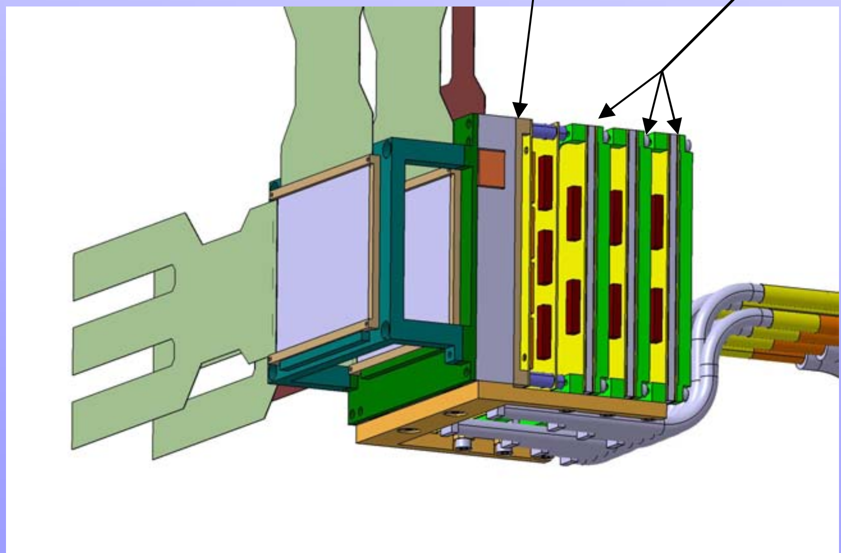


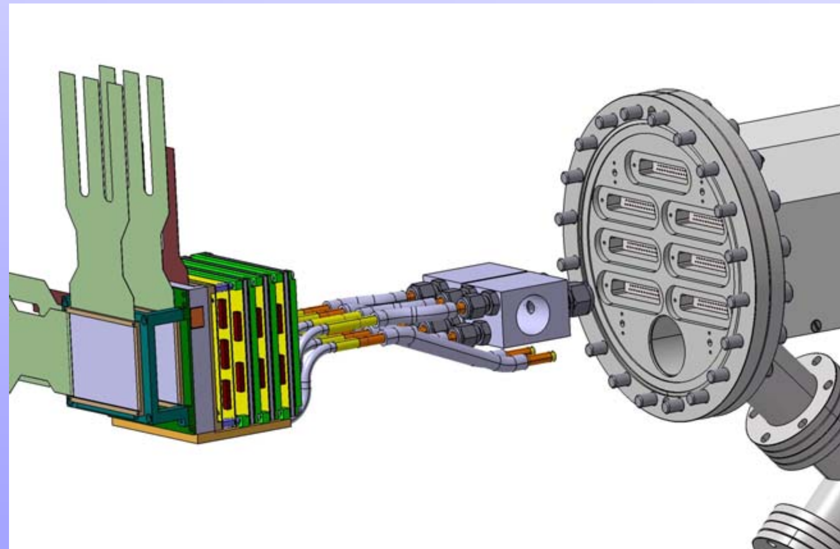


cooling plate

cooling liquid

detector cooling for the Si(Li)





Spin-Filtering: Questions.

Spin-Filtering: Questions

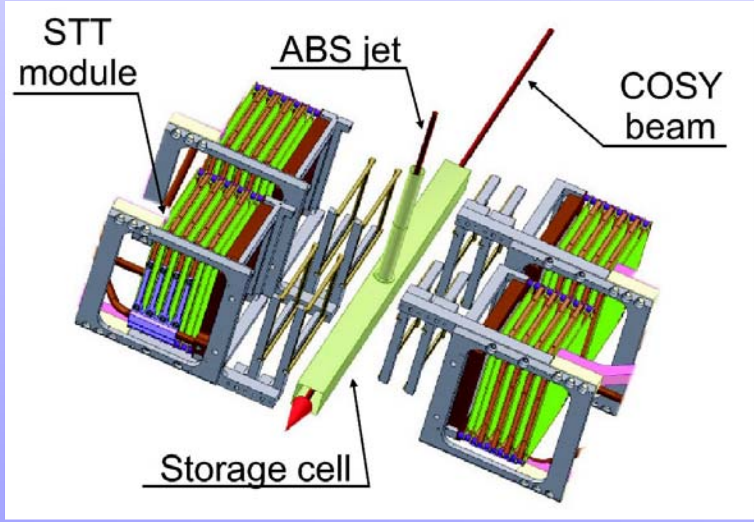
Optimize for pp-elastic only?

Identical setups for COSY spin-filtering and the AD-experiment?
- Openable cell?
- Can we escape from a strong longitudinal holding field?

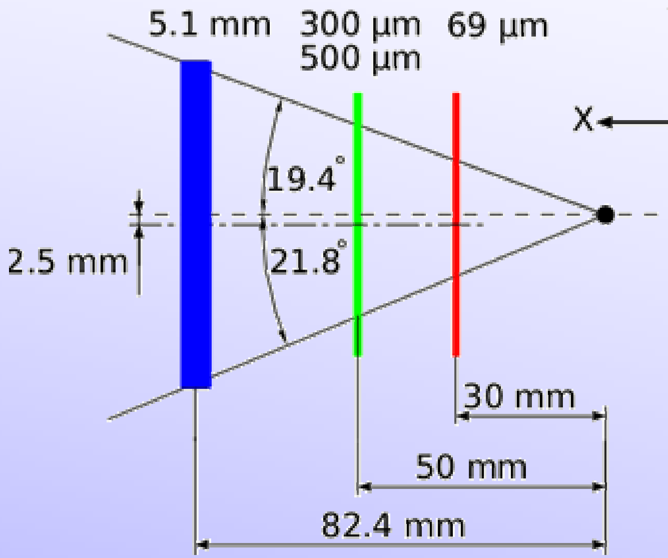
Magnetic field configuration?

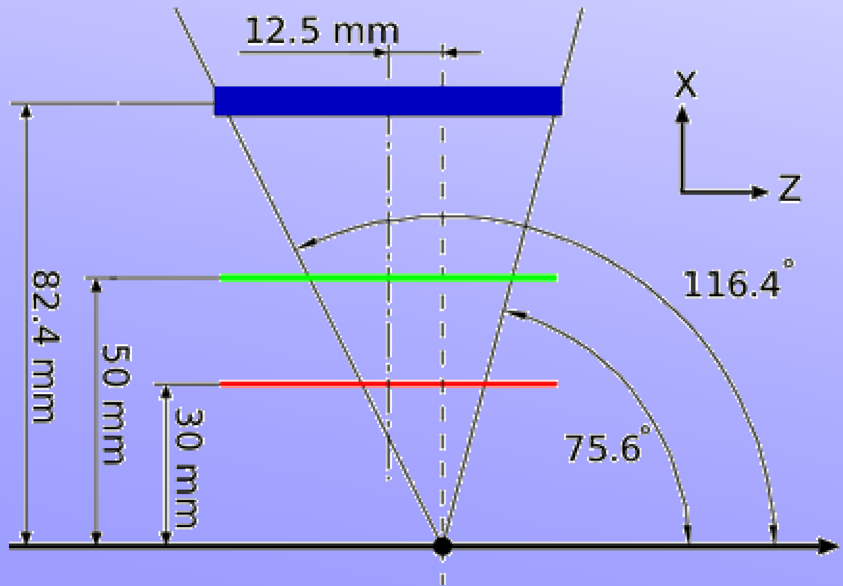
CERN UHV conditions?

Vacuum-break protection?



Measurements at the ANKE cluster target

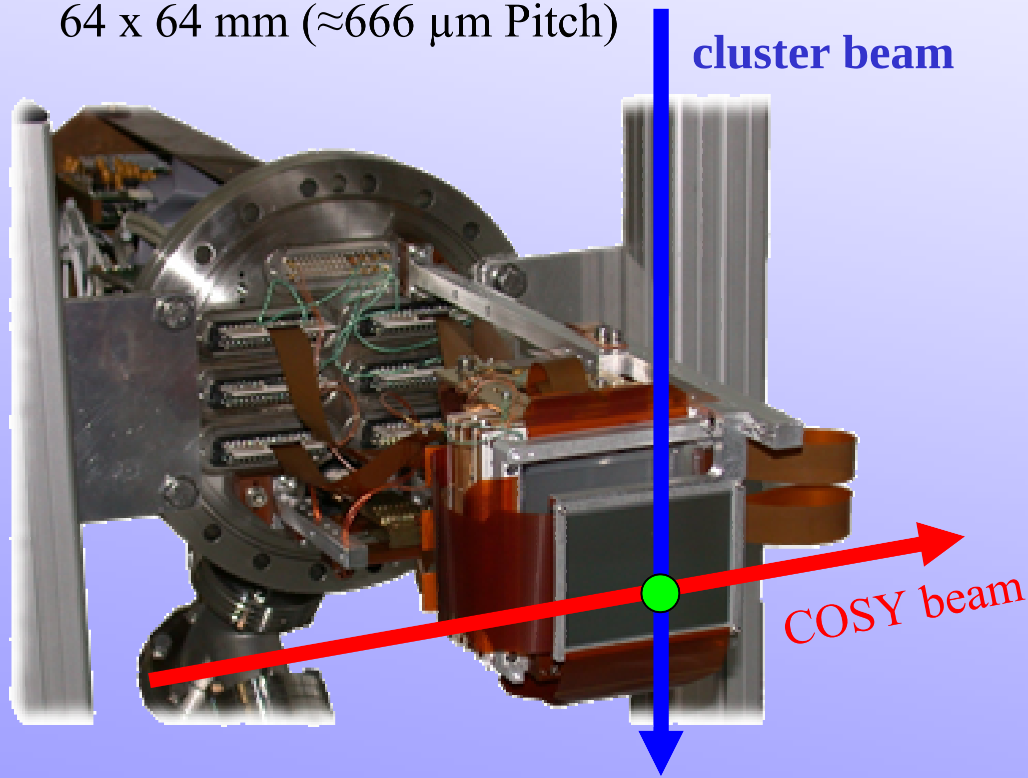




- 3 silicon detector layers
  - → 69 µm silicon
  - → 300/500 µm silicon

    128 x 151 segments
    51 x 66 mm (≈400 µm pitch)
  - → >5 mm Si(Li)

    96 x 96 strip
    64 x 64 mm (≈666 µm Pitch)



Spin-Filtering: Questions

$p\vec{p},\ p\vec{d},\ p\alpha,\ \bar{p}p\ elastic\,?$

Find the appropriate detector layout(s)

- What is the energy range of interest (40-800MeV)?
- one detection system for all energies?

Detection concept?

- single/double particle tracking?
- combined ΔE/E particle identification?
- number of layers?
- thickness of detectors?

Background suppression

- segmentation?
- time-resolution?

Spin-Filtering: Organization?

Spin-Filtering @ COSY
Where Do I Place Which Detectors?

Misha Nekipelov, Ralf Schleichert, David Yamanidze
19. July 2006

Version 0.0a

Detectors:
a) 50x60mm^2, 60mm along the beam axis.
b) 1mm pitch.
c) 20-50mm distance to the beam axis
d) 70, 300 and 500um are available.

Event Generator:
a) Pluto pp-elastic
b) include differential cross-sections and analysing-powers from the SAID data base.

Target:
a) take a point-like target for the beginning.
b) Extended target: 40cm long, triangular shaped density distribution.

Single telescope (no coincidence), two planes: z1=z2=+30mm, x1=50mm, x2=70mm
For each of the conditions
a) Tbeam=40MeV, d1=300um, d2=300um
b) Tbeam=40MeV, d1=70um, d2=300um
c) Tbeam=800MeV, d1=300um, d2=300um
d) Tbeam=800MeV, d1=70um, d2=300um
show the following spectra
i) Kinetic energy and theta distribution for the non-detected proton.
ii) E vs dE1, E vs. dE2, dE1 vs. dE2 (kinetic energy in MeV).
iii) detection threshold per detector segment.
iv) count rate per segment.